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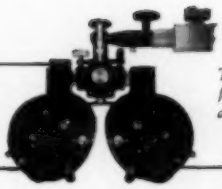

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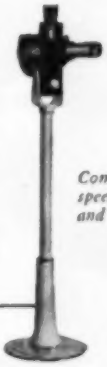

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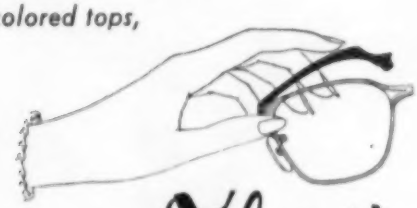

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CATARACT AND ITS ETIOLOGY*

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Cataract is a disease which was known to the ancient Greeks and Romans. These people visualized the cataract as an opaque liquid lying between the iris and the lens. They imagined that the liquid "fell down" in front of the lens; hence, we derive the name, "cataract." This opaque liquid was considered to be a diseased "humor" that descended from the brain to a position between the cornea and the lens. It was not until the 18th century that the true nature of cataract as a lenticular opacity was revealed by the French army surgeon, Brisseau.

Subjectively, cataract may be manifested to the patient in a variety of ways. Black spots may appear before the eyes and move with the movements of the eyes. Uni-ocular polyopia may be present because of irregular refraction within the lens. This irregular refraction may produce diffraction haloes around lights. Lenticular myopia may result because of nuclear sclerosis. Finally, of course, there may be a progressive failure of vision. In this respect, nuclear sclerosis generally interferes with vision to a larger extent than does the cortical opacity. On the other hand, if peripheral cataract exists, the visual acuity, although actually diminished, may appear to improve when the illumination is bright enough to constrict the pupil. This diminution of vision may depend not only upon the size and density of the lenticular opacity but also upon its position. Thus, a small opacity at the nodal point may cause marked interference with vision.

It is interesting to note that partial cataract is relatively common in a random selection of individuals. Doggart (1946) found the following distribution in a group of 30 men with no ocular symptoms whose ages ranged from 19 to 60 with an average of 28.2 years:

(a) 94.3% had some type of lenticular opacity;
(b) 93. % showed the presence of scattered dots;
(c) 6. % had coronary cataract;

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†Optometrist, Ph.D. Member of faculty. Fellow, American Academy of Optometry.

(d) 4. % had anterior axial embryonic cataract;
(e) 1.3% showed dilacerated cataract; and
(f) 0.3% had senile cataract.

General Pathology

Since the crystalline lens has no blood vessels, its pathology is much simpler than that of other ocular structures. For example, no inflammation is possible. The only cells capable of regenerative activity or of response to irritation are those of the epithelial layer beneath the anterior capsule. However, many conditions may affect the chemistry of the lens so that degeneration and opacification may result.

Basically, cataract may be considered to be a loss of transparency due to altered physico-chemical processes. This loss is caused by a disturbance in the intimate structure of the lens, the fibers of which form a colloidal system in which a large amount of water is bound. The disturbance may be one of two kinds, either (a) a swelling opacity, which is a reversible change and produces a diffractive effect only, or (b) a coagulation opacity, which is an irreversible change and may occur in two stages as follows:

(1) A *denaturation* whereby the protein is altered chemically to an unstable, readily coagulated form, but is still transparent; and

(2) An *agglutination* which is a physical change producing coagulation by the flocculation of the denatured particles.

The degenerative sclerotic or necrotic changes of the lens fibers may be associated with some aberrant activity of the lenticular epithelium. In sclerosis, the change is analagous to a keratinization of the epithelium of the skin, but since the cells in the lens cannot be exfoliated they are retained. If the sclerosis is irregular, it may affect the transparency of the fibers as well as the refractive condition. Necrosis may be associated with edema which interferes with the optical transparency temporarily, as in early diabetic changes, or it may be associated with alterations in the colloidal system as the result of a contusion, after which peptization of the protein may result in a return of transparency. In a young lens, proteolysis may be so complete that the lens becomes entirely absorbed. In an older lens, the nucleus may be unchanged but the cortex may become a pultaceous mass.

CLASSIFICATION OF CATARACT

Congenital Cataract

Cordes (1947) has given an extensive discussion in this field. He indicates that any arrest in development may cause a change in the lens. Thus, a delay in the closure and separation of the lens vesicle from the surface ectoderm permits the lens fibers to grow forward and protrude

through an opening in the lens capsule, thereby producing an anterior capsular opacity. A failure in development of the lens fibers from the cells of the back wall of the lens vesicle may lead to an absence of the central portions of the lens and may result in congenital disc-shaped cataract. Because of the method of growth of the crystalline lens, an opacity left by an injury to the lens in childhood may be found in adult life in the deeper layers.

Congenital lens opacities include anterior axial embryonal cataract, anterior polar cataract, posterior polar cataract, posterior lenticonus (in which the central part of the lens becomes highly myopic), and zonular (lamellar) cataract. It may be stated that congenital opacities do not represent an arrest in development but rather an aberration since the lens is normally transparent in development.

Evolutionary Lenticular Opacities

These are stationary and non-progressive and generally result in little or no visual impairment.

Punctiform Opacities (Blue Dot Cataract)

Blue and white spots are seen in the lens with the aid of the slit lamp.

Coronary Cataract

The opacities are in a corona in the outer layers of the adult nucleus and the inner layers of the cortex.

Senile Cataract

In this more common type, the changes may take the following forms: (1) Vacuole formation under the capsule or in the lens interior; (2) the formation of clear radial clefts; and (3) the appearance of lamellar separations, usually in the anterior cortex after the age of 50. (The separation of the radial lamellae may be in a series of fine parallel lines.)

This may occur in about 25% of the cases as *nuclear* cataract with the nuclear portions having a different chemistry from the cortex. In the other 75%, the cataract is said to be cortical. An ill-defined haze in the cortex leads to the denaturation and coagulation of protein with the formation of true opacities of several types, depending on the location and appearance of the opacities.

Pathological Cataract

This is a very large category which includes the following: (a) *Diabetic* cataract; (b) *endocrine* cataract, which may appear in aparathyroidea and tetany, in myotonic dystrophy, in mongolian idiocy, and may be associated with certain types of skin diseases, such as scleroderma and neurodermatitis; (c) *toxic* cataract, which may be

caused by dinitrophenol poisoning or acute toxic illness, such as diphtheria, malaria, typhus or cholera; and (d) *complicated* cataract, which may follow intra-ocular disease.

GENERAL ETIOLOGICAL THEORIES

Bellows and Chinn (1951) state that etiological theories may be divided into (a) those involving physical or chemical derangement and (b) those involving senile involutional and hereditary factors. They point out that etiologic factors of the first division may be studied experimentally and may be subdivided into endocrine dysfunction, decrease in nutrient supply, intoxication of the lens, changes due to radiant energy, alterations in capsular permeability, osmotic changes and refractive errors.

Endocrine Dysfunction

Cataract has been observed with cretinism, mongolian idiocy, tetany, diabetes and gonadal insufficiency. It also occurs in idiopathic conditions believed to be dependent on an imbalance of internal secretions, namely myotonic dystrophy, neurodermatitis, and scleroderma.

Decrease in Nutrient Supply

A condition of poor nutrition may occur surgically, clinically or experimentally. Thus, ligation of the posterior ciliary arteries or of the vortex veins may result in cataract. Clinically, uveal stasis or congestive glaucoma may have similar effects. Generalized avitaminosis has been cited by many as an important cause of cataract. It is conceived that a decreased intake of riboflavin may be a contributory factor. Lenticular changes, however, may be secondary since this deficiency produces other ocular pathology and the research of several workers has indicated the absence of riboflavin from the normal lens.

Intoxication of the Lens

It is uncertain whether some substances such as paradichlorbenzene, ergot, and dinitrophenol produce cataract because of cytoplasmic poisoning or because of derangement of the lens metabolism. Since the liver is one of the most important detoxifying organs of the body, a relation between hepatic damage and the formation of cataract from toxic agents is possible.

Radiant Energy Changes

Radiant energy may affect the lens directly, causing an opacity, or it may produce changes in the ciliary body so that the lens loses transparency secondarily as a result of alterations in the nutrient fluid. Different investigators disagree as to the method by which heat waves exert their injurious effects. Some believe there is a direct action in which

the heat waves are specifically absorbed to cause a colloido-chemical change in the lens. Others believe that the action is indirect and that the iris is the mediating agent. This opinion is supported by the fact that cataract develops more rapidly in pigmented animals than in albinos. Roentgen rays may act either on the ciliary epithelium which might then modify the lens transparency, or they may act directly on the lens. Electric currents may affect the lens. Many theories have been presented to account for the action of electric shock in producing cataract.

Capsular alteration

Any abnormality in the capsular membrane may lead to changes in the lens fibers, since the avascular lens must depend on its immediate surroundings for a nutrient supply. This would tend to explain the fact that cataract so often results from iridocyclitis. Cell deposits, pigments, exudates, etc. on the lens capsule would markedly interfere with the nutrition of the lens.

Decrease in Lens Permeability

A challenging study has been reported recently by Monahan (1953) on the channels which have been observed in the human lens capsule. Hitherto, the permeability of the lens capsule, which permits the passage of particles of small molecular size and blocks those whose size approaches the visible range, has not been adequately explained. Monahan claims that this permeability is caused by a complex system of channels which course through the periphery of the lens capsule and permit the entrance of modified aqueous into the lens. The channels were observed with a phase-contract microscope. A number of reasons are advanced for supposing that these channels are not artefacts. Monahan found that these channels are branched and of lower optical density than the surrounding lens capsule. The largest visible channels were found to be 0.5 microns in diameter and the smallest about 0.2 microns. Monahan reports a close correlation between the presence of the channels and the state of the lens tissue. Thus, the channels are diminished in number and extent in lenses with immature cataract and absent in lenses with mature cataract. Monahan believes that senile cataract is caused by a loss of metabolic exchange in the lens and that this is brought about by closure of the lens capsule channels.

Osmotic Changes

In the passage of nutrient material from the blood to the lens, the two barriers to be traversed are the ciliary processes (blood-aqueous) and the lens capsule (aqueous-lens). The same two barriers in reverse order oppose the removal of the waste products of lenticular metabolism. Cataract may be experimentally produced by the injection of

hypertonic solutions, but other contributing factors may exist. In cholera, cataract may develop where there is marked dehydration.

Hereditary Factors

According to some authorities, cataract development is governed by hereditary factors and may be compared with graying of the hair, which develops at different ages in different individuals. However, the findings in senile cataract are too diverse to be explained so simply.

THE METABOLISM OF THE LENS AND ITS CHEMISTRY

Our knowledge of the normal and pathological metabolism of the lens is still small, although it is increasing rapidly. We do know that one of the most important processes in the lens is carbohydrate metabolism in which the greater part of the necessary energy is derived from the breaking down of glucose. Glycolysis is an anaerobic process which breaks down glucose into lactic acid. This process seems to be more active in the nucleus than in the cortex. An additional aerobic process occurs whereby lactic acid is broken down into carbon dioxide and water.

Duke-Elder states that metabolically the most important features in the development of cataract are a diminished metabolism, a decrease in permeability, and a loss of substances active in oxidation, such as cystein, glutathione, and ascorbic acid. Whether the relationship is casual or consequential, Duke-Elder states in either case the cataractous lens is an asphyxiated lens.

Christiansen and Leinfelder (1952) state that evidence shows that the oxidative reaction of isolated lenses is non-enzymatic and that the lens does not respire in the usual sense of a thermo-labile enzymatic reaction with oxygen. These authors state that respiration can be of only slight importance in the energy metabolism of the lens.

With respect to pH, evidence shows that as cataract develops there is first an acid tendency and then a shift which changes the pH of the lens towards alkalinity as maturity is reached. The acid shift is related to proteolysis while the alkaline shift is related to the deposition of calcium.

Using rats as experimental animals, Hart and Peckham (1953) observed an increase in the specific gravity of the lens with age. These workers suggest that a comparison may be made of decreasing amplitude of accomodation with age in human beings, since there is a possibility of the decrease in plasticity of the lens being related to an increase in specific gravity.

The lens protein consists of alpha crystalline, beta crystalline, gamma crystalline, albuminoid, traces of nucleo-proteins and traces of

muco-protein. As the lens ages or becomes cataractous, alpha crystalline decreases while the albuminoid increases and beta crystalline remains relatively constant. With the increase of albuminoid, the lens fiber holds less water and becomes more dense optically. Suellmann (1944) states that the amino acid tryptophane constitutes 3.5 to 5.3% of the total protein, with most of this contained in the beta crystalline portion and the least of it in the alpha crystalline portion.

In an interesting study, Kinsey and Merriam (1950) come to the conclusion that glutathione and protein in the lens are being constantly synthesized from their constituent amino acids. In the cataractous process, the reduced concentration of glutathione may result primarily from an inhibition in its synthesis due to the poisoning of one or more enzyme systems, either those directly responsible for synthesis or those responsible for providing energy for the synthetic process.

In a study on the cholesterol content of cataractous human lenses, Salit and O'Brien (1935) found that there is no difference between normal and cataractous lenses of the same age with respect to the cholesterol content. However, they observed that the cholesterol content does increase with age.

Fromm and Kinsey (1952) found that the concentration of utilizable high-energy phosphate in the rabbit lens is highest in the epithelium and that it appears to vary inversely throughout the cortex with the distance from the epithelium. A very small quantity is present in the nucleus. The concentration of the storage form of high-energy phosphate was found to be lowest in the epithelium and highest in the posterior cortex. These writers state that a reduction in the processes of synthesis observed in cataractous lenses is due to a decrease in available high-energy phosphate.

Milano (1941) found that the normal human lens has a high phosphorus content but that the content is reduced in cortical cataract.

Henkes (1944) studied the distribution of vitamin C in the lenses of cattle, guinea pigs, rabbits, rats, mice, and cats. The lenses were examined by microtitration and by histochemical methods. It was found that the lens capsule and epithelium have little vitamin C content. The peripheral cortex of the lenses has the highest vitamin C content, which decreases more slowly toward the inner cortical parts and then decreases still more abruptly in the lens nucleus.

The water content and solids of cataractous human lenses was reported by Salit (1938). The percentage of water in incipient cataracts averaged about 66.2% and gradually increased to 77.8% in hypermature lenses. The solid content ranged from 69.6 mg. per lens in incipient cataracts to 48.4 mg. in mature cataracts.

The origin of pigment in the lens has received considerable speculation. Bellows (1935) states that protamine may split off from nucleoproteins in the nuclei of the lens fibers and then escape into the cytoplasm through the nuclear membrane where it may precipitate and react with cysteine to form melanin. If there are more nuclei and more protamine involved in the reaction, the color goes from yellow to dark brown. Fischer (1940) states that the yellow to brown substances in the aging lens are melanoidines, which are condensation compounds of amino acids or amines with carbohydrate. These are said to protect the eye from the toxic action of the catabolic products of protein disintegration.

The chemical pathogenesis of cataract is discussed by Krause (1938). He points out that the initial chemical effect is quite variable and depends on the type of cataract. Thus, in traumatic cataract the initial effect is said to be an increase of acids, in diabetic cataract an increase in the organic acids, and in myotonic cataract an interference with creatine metabolism.

Hereditary Cataract

Lutman and Neel (1935) trace the genealogy of a cataractous family extending over 5 generations and comprising 123 people, 44 of whom had cataract from childhood on. Although there was only one pedigree, there were three distinct types of cataract formation. This may have been due to the simultaneous presence of two different independently inherited factors in the founder of the line, to mutation, or to the existence of a genetic and environmental modifier which brought about a variation in the expression of the "main factor."

Vinsonhaler and Cosgrove (1936) present a history of hereditary cataract in six generations. No generation was skipped. Cataract development tended to appear earlier in life in succeeding generations. The individuals involved, incidentally, were healthy, fertile, and lived to normal expectancy.

Von de Heydt (1940) reports a case of familial progressive juvenile cataracts. This patient was the victim of a recessive hereditary parathyroid deficiency of sufficiently severe degree to give rise to cataract of the tetanic type.

Johnstone (1947) presents a history of a group of 73 individuals of whom 23 are affected. The distribution between males and females is about equal and those involved were otherwise healthy.

Hereditary nuclear cataract is discussed by Lee and Benedict (1950). In six generations, 63 individuals out of 200 were affected. The writers state that it is probable that the cataract affects only the

fetal nucleus and not the embryonic nucleus. It would seem that the cataract does not reach its final stage of development, when it becomes stationary, until the affected individual reaches the age of two. The characteristic is not sex-linked and there is an even distribution among males and females, with no evidence of associated mental deficiency.

Congenital Cataract

Of relatively recent interest is the relationship of rubella in the mother to congenital cataracts. Apparently the first report of German measles in the mother producing cataract in her offspring occurred in 1942. It has been found that if the mother has German measles during the first two months of pregnancy there is about a 100% chance for cataract development in the child, while if it occurs at about three months there is about a 40% chance, and thereafter a drop in incidence. The cataractous eyes of such affected offspring are usually microphthalmic with a very hard embryonic nucleus in the lens.

Duke-Elder (1951) suggests that the cataract may occur because there is interference with the nutrition of the developing lens through some action of the hyaloid artery. However, it must be remembered that the hyaloid artery persists until shortly after birth, while it is the rubella infection which occurs during the first few months of pregnancy that is very dangerous. Another theory postulates that in rubella a virus invades the fetus and infects the epithelium of the developing lens vesicle.

Cataract and Refractive Errors

According to Jackson (1938), eyestrain through accommodative fatigue may be an important factor in the production of cataract. He states that the lens fiber acts like a muscle cell and responds to stimulation by pressure, just as do the unstriated muscles of the intestine. It is also thought that the increased effort of accommodation may cause ruptures or tears in the capsule as the result of excessive traction on the zonular fibers. In this respect, hyperopia and astigmia would theoretically have a greater influence on the production of lenticular opacities than would myopia. One objection to this theory is that, according to the Helmholtz theory of accommodation, the zonule is relaxed during accommodation. Also, cataract does not develop after prolonged periods of ciliary spasm. Thus, the effects of the extensive use of miotics or the incidence of strychnine convulsions do not produce cataractous changes despite the accompanying ciliary spasms.

Auricchio (1951) made a study of the morphology of crystalline lenses in cases of myopia above 10 diopters and correlated the findings in each case with the age of the patient. He concludes that there is in

myopia of this type a state of dystrophy of the lens fibers which results in an increased loss of transparency. These changes, however, appear late in the history of the condition and are secondary to alterations of the choroid and retina. Changes in the choroid may indirectly influence the process of nutrition of the crystalline lens.

Lipids and Cataract

Lipid deposition in the lens increases normally with age. It also increases in cataract formation. This fatty deposition with age may be comparable to the common process of fatty deposition in senile and degenerating tissues, depending essentially on a lessening of oxidative activity.

Salit (1936), writing on the phospholipid content of cataractous and sclerosed human lenses, states that pathological lenticular sclerosis and cataract appear to be more or less related, both being due to an autolysis or disintegration of the lens tissue. The phospholipid content of highly sclerosed lenses decreases just as in cataractous lenses when they approach maturity. In metabolic disturbances, the proteins, especially the insoluble albuminoids, may be freed from the emulsifying agent, the phospholipid, and this may give rise to sclerosis. Salit states that the pathological lenticular changes in age are marked by disturbances in fat metabolism, specifically by changes in the behavior of the phospholipids. Cataract is found chiefly in the cortex, while sclerosis occurs chiefly in the nucleus. Therefore, according to Salit, cataract represents chiefly changes in the crystalloids while sclerosis represents changes in the albuminoids and in the lipids.

In further studies, Salit (1937) found that there is a slight increase in the total lipids as a cataractous condition advances from the incipient to the mature stage. In intumescent cataract, phospholipids constitute 28.4%, cholesterol 28.9% and fat 42.7% of the cellular material. In mature cataract, the figures are 25.7%, 30.1%, and 44.2%, respectively.

Cysteine and Cataract

Dische and Zil (1951) state that the soluble proteins of normal lenses contain much more cysteine than cystine. The oxido-reductive equilibrium between the two amino acids is shifted toward cystine in lenses with senile cataract. This shift may appear even in the non-opaque portions of partial cataract. The sum of cysteine and cystine in the albumoid is considerably increased in total cataract.

In an interesting report, Von Sallmann (1952) demonstrates that intravenously administered cysteine has a strong protective action

against radiation damage to the lenses of rabbits. In his experiments, this protection lasted for 18 months.

Galactosemia Cataract

Bellows (1936) found that galactose in the diet of the albino rat produces cataract and that galactose in some way causes a loss of sulfhydryl content in the crystalline lens. As a result, the internal oxidative system of the lens is insufficient to support the life of the tissues. Cystine and vitamin C were found to be effective in delaying the onset of this type of cataract. It is theorized that senile cataract may arise as a result of a sudden or gradual loss of cysteine.

Cashell and Kon (1939) produced galactose cataract in rats by feeding this substance to them. The cataract commenced with a dense film of fine bubbles at the equator of the lens. Discontinuance of the galactose feeding produced a regression of the cortical cataract, but did not diminish the nuclear opacity.

In discussing human galactosemia cataract, Enns (1951) states that excessive galactose, due to an apparently decreased ability of the liver to convert galactose to glucose, may cause cataract as well as anemia. If a galactose-free diet is used early, the cataractous changes may be reversible. The mineral composition in this type of cataract is similar to that in senile cataract. There is some evidence, according to Enns, that galactose is toxic to the capsular epithelium or may be toxic to the lenticular tissue, because it produces a disturbance of the internal oxidative mechanism.

Reiter and Lasky (1952) report that there is a striking similarity between the evolution of experimental galactose cataract in the rat and lamellar cataract in the infant. They cite the case of an infant who had galactosemia and associated lenticular opacities which were slowly resorbed to complete transparency. The writers state that treatment in the human after three months is unlikely to achieve complete regression, but that treatment given before the age of three months may produce a complete regression.

Patz (1953) describes a case of galactosemia cataract. Most commonly, the opacity appears as a central refractile ring resembling the "oil drop" effect of lenticonus. Clusters of cortical vacuoles and various forms of zonular cataract have been observed. Patz urges periodic examination in the management of patients with galactosemia in view of the rapid cataractogenous effect of the disease.

The relation between cataract and the presence of carbohydrates was studied experimentally by Patterson (1953). He found that galactose and glucose act in a synergistic fashion in the production of cataract.

This has been interpreted as indicating that these sugars produce their effect in a similar manner. Patterson found that rats which were placed on a 35% galactose diet for four days of the week and then starved for three days of the week developed cataracts in an average of 40 days. However, rats which were placed on an identical galactose regime but were also given a supplement consisting of a normal diet, instead of being starved for three days each week, did not develop cataracts. Patterson interprets this as indicating that carbohydrate cataracts are the result of a metabolic deficiency which could be corrected by a proper supplement to the diet at a time when the cellular absorption mechanisms are not blocked by a high sugar level.

Calcium and Cataract

Cataract may be associated with tetany, in which condition the calcium content of the blood is lowered (hypocalcemia). Numerous studies have been made on the relationship between cataract, blood calcium, and the condition of the parathyroid glands, whose function it is to regulate calcium metabolism. Clar (1939) found that when a combination of parathyroid extract and calcium salts was added to solutions in which pig lenses were immersed, that the penetration of calcium into the lens tissue was completely inhibited. He suggests that one cause of the occurrence of cataract after parathyroidectomy may be a greater permeability of the lens capsule to calcium in the absence of the parathyroid hormone.

Bahr (1940) performed laboratory experiments on the pathogenesis of tetany cataract. He found that isolated rabbit lenses kept in artificial aqueous humor of reduced calcium content experienced cataractous changes similar to those seen in tetany. Inasmuch as the extent of the lenticular changes observed bore no relation to the amount of hypocalcemia, it does not appear, according to Bahr, that the hypocalcemia alone produced the cataract. Bahr assumes that a cataractogenous substance is present in the serum and blood corpuscles and that hypocalcemia, by increasing the permeability of the lens capsule, permits the entrance of this substance into the lens. This cataractogenous substance may be a normal constituent of the aqueous humor.

Rauh (1939) reported that the use of dihydrotachysterol will retard the progress of tetanic lenticular opacities in rats. He suggests the use of this chemical as a prophylactic measure.

The importance of preventive measures and early diagnosis in hypocalcemia is stressed by Weekers (1944), who states that vitamin D and parathyroid extract may, in favorable cases, prevent and retard the development of cataract.

A more recent contribution to the pathogenesis of tetany cataract has been made by Brand (1950). Brand concludes that hypocalcemia is not a factor in the genesis of this type of cataract and that the increased permeability of the lens capsule alone accounts for the passage of a considerable amount of calcium into the lens. He suggests that it is this added calcium content which promotes the development of cataractous changes. The change in the permeability of the lens capsule is attributed by him to some hormonal factor.

Cataract and Diet

The relationship of diet to cataract is a rather obvious point of investigation. Although it may be of greater importance in some types of cataract than in others, it furnishes for all an open source of attack.

Yudkin (1939) says that the diet should be adequate. He finds that cataract in young albino rats may be produced by diets deficient in vitamin B_2(G). A small amount of riboflavin added to the diet of these animals prevented the onset of the opacities.

Dodge (1935) found that diets high in certain carbohydrates produced microscopic changes in the lenses of white rats. The use of dry skimmed milk was found to reduce the magnitude of the lenticular changes. Dodge concludes that a correlation may exist between the sequence of intestinal digestion, the absorption of sugars and the corresponding level of blood sugar, and the degree of cataract formation.

Tryptophane deficiency may produce experimental cataract in rats, as reported by Buschke (1943). Administration of tryptophane to these experimental animals may arrest the formation of lenticular opacities.

The subject of the relationship between vitamin C and cataract has received a great amount of attention. Bellows (1936) found that cataractous subjects have a distinctly lower concentration of cevitamic acid (ascorbic acid, vitamin C) in their blood plasma than do normal subjects. He concluded that a lowered amount of this substance in the aqueous and in the lens of the cataractous eye precedes the development of the opacities. Bertoldi (1939) found that cataractous patients eliminated 5% less ascorbic acid in the urine than did controls. He holds the view that cataractous patients suffer from a vitamin C deficiency. Muhlmann and Bachmann (1939) administered vitamin C to 60 patients with incipient, immature, and mature senile cataracts of both the nuclear and the cortical types. Injections of 50 mg. of vitamin C were given two or three times weekly. These were increased to 100 mg. for the last of 20 injections over a period of two months. Then, after two months of rest, another two months of treatment fol-

lowed: this was continued for two years. At the end of that time, the writers reported an improvement in vision in 51% of the patients treated, no change in 38% and a diminution of vision in 9%. The greatest improvement was seen in incipient cataract. Jeandelize and Bardelli (1939) found that subjects with completely opaque senile cataract suffered almost constantly from vitamin C deficiency. They reported improvement in the visual acuity of 13 patients to whom vitamin C had been administered. Pavia and Morate (1944) reported beneficial effects of the use of vitamin C on patients with immature cataract, but little effect on mature cataract.

In spite of the findings mentioned above, at present there is no firmly based evidence that dietary changes may affect the progress of cataract. We must await with patience any developments in the future.

Diabetes and Cataract

Diabetic cataract has been subdivided by Duke-Elder into two types. These are (a) the ordinary cataracts of the senile type which occur more frequently in diabetics, appear at an earlier age than usual and tend to progress more rapidly to maturity; and (b) the more rare, true diabetic cataracts which occur bilaterally, present an acute condition and are found more commonly in young persons.

Surveys made among diabetics of all ages have shown 36% with clear lenses and 64% with some type of opacity. The proportion of opacities is considerably higher among diabetics than in the normal population. It has been shown that the severity of diabetes makes little difference in the incidence of cataract, but that the duration of the disease is important in determining the incidence of the lenticular opacities.

Numerous theories have been proposed to account for cataractous formation in diabetes. Lawrence (1946) states that adequate control of the systemic condition may result in the disappearance of opacities which are due to edema, provided they are not of long standing.

Rosen (1945) states that the appearance of "diabetic needles" in the lens is diagnostic of diabetic cataract. With a dilated pupil under indirect ophthalmoscopy or retinoscopy, a "spoke" formation may be seen in the periphery of the lens in the form of a multi-linear black streak. Rosen says that an important diagnostic feature of diabetic cataract is that the "spokes" are no thicker at their periphery than at their central termination. This "needle" formation, according to Rosen, may be superimposed upon ordinary adult "spoke" formation in early senile cataract.

Paras (1949) found that the administration of the drug, alloxan, produces a brief hyperglycemia in the rat. This is followed by a hypo-

glycemia and lenticular changes which tend towards the formation of diabetic cataract within two months.

Cramer and Foglia (1948) produced cataract in the rat after extirpation of 95% of the pancreas. The major lenticular changes were found in the cortex.

In more recent studies on experimental diabetic cataract in rats, Patterson (1952) found that at first vacuoles are observed around the periphery of the lens. Later, fine crystalline opacities develop centrally and still later the lens becomes opaque. The diabetes in these animals was induced by drugs which destroyed the beta cells of the islets of Langerhans. Insulin treated rats, however, maintained clear lenses.

Cataract and Radiant Energy

This subject has received considerable investigation recently. In large part, the emphasis may be due to the general studies that are being made on the clinical and physiological effects of the products of nuclear fission, the products of the decomposition of the transuranium elements, etc. The fact that cataract was one of the after-effects of the atomic bomb explosions in Japan has encouraged numerous clinical and experimental investigations on this subject in the past few years.

Radiation can be effective only insofar as it is absorbed. The crystalline lens can absorb a very large proportion of infra-red radiation between 11,000 and 14,000 a.μ., but a sufficient proportion of ultraviolet, from 2,930 to 4,000 a.μ., also penetrates the cornea and is absorbed by the lens. It is, therefore, possible that daylight may conceivably be an effective agent in producing cataract by its thermal and abiotic actions. It has been shown that workers in occupations which require a considerable exposure to bright light show a higher incidence of cataract than do other workers. Uni-ocular cataract tends to occur more frequently among industrial workers on the side of constant brilliant illumination. In addition, senile cataract tends to commence in that lower quadrant of the lens which receives the incident light more directly.

Duke-Elder points out that radiant energy could either have a direct effect on the lens or that it could irritate the ciliary body and thus alter the composition of the nutrient fluid to the lens. It is possible that radiant energy may effect a slow denaturation of lenticular protein over a long period of time, thus putting the colloidal system into a more labile state so that it can be coagulated more readily by other factors.

Bellows and Chinn (1941) state that it is interesting to note that animals sensitized with hematoporphyrin and exposed to sunlight

develop lenticular opacities. This photosensitization is strongly suggestive of pellagra in which severe dermatitis may be precipitated by exposure to sunlight. In pellagra, the excretion of porphyrin is markedly increased and is thought to be a sensitizing agent for the cutaneous eruptions. Since the skin and lens are embryologically similar, it would be interesting, according to these writers, to investigate the relation between pellagra and cataract in certain countries such as India, where there is a brilliant intensity of sunlight and a widespread deficiency in diets.

Electric Cataract

The pathenogenesis of electric currents was studied by Bellows and Chinn (1941). These workers exposed the eyes of freshly killed cattle to sparks of high voltage, low frequency currents for short periods of time, one to 10 seconds. They then removed the lenses and placed them first in pooled vitreous humor and then in distilled water. The swelling of these lenses was compared with the swelling of control lenses which had not been subjected to the electric current. The exposed lenses exhibited a marked decrease in swelling as compared to the controls. This decrease was more noticeable with high voltages and also more noticeable with high frequency currents than with low frequency currents of comparable voltage. Passage of low voltage currents through Ringer's solution containing the lenses also decreased the swelling tendency. It was also observed that direct current decreased the swelling even more than did the alternating current. Bellows and Chinn do not offer a clear explanation. If there is damage to the corneal epithelium and endothelium; *more*, not *less*, water should be taken in, and this is also true if there is injury to the lenticular epithelium.

Godtfredsen (1940) believes the lens changes may be attributed to electrothermal injury to the epithelium of the lens capsule, the opacities being the results of disturbances in nutrition.

Cataract and Microwaves

Richardson et al (1951) produced cataract experimentally in rabbit eyes *in vivo* and also in excised beef eyes by means of three-centimeter pulsed microwave irradiation. Of 21 rabbits treated, 16 developed opacities within 60 days. Since this type of wave is used in radar work, the authors suggest the use of copper or bronze screen wire as a protection to cover the eyes and head.

Lavine et al (1952) determined the effects of ultrasonic waves on the refractive media of the eye. At first, the study was instituted to determine whether lenticular opacities could be cleared by means of ultrasonic irradiation. Excised calves' eyes were used. It was hoped

that the ultrasonic waves would provide a means for the disruption and ultimate liquefaction of opaque lens protein and lens fiber systems in clinical cataract. This hypothesis was based on reports that large molecules can be broken up into smaller ones by ultrasonic waves. Unfortunately, the results were merely to produce a new type of experimental cataract.

Roentgen Irradiation and Cataract

Numerous studies have been made in this field. Poppe (1942), working with rabbits, found opacities in the region of the posterior pole of the lens about four months after exposure to x-rays of 1500 r in 45 minutes. It is postulated that pathological alterations occur in the lens epithelium, thus interfering with lenticular nutrition.

Von Sallman and Locke (1951) found that experiments with radio-active indicators did not lend support to the theory that it is the enhanced permeability of the lens which leads to the development of opacities produced by roentgen rays. They suggest that these changes accompany and possibly influence the progress of opacification.

Cogan and Donaldson (1951) reported on an extensive study on experimental radiation cataract. Cataract was induced in rabbits by exposure to x-rays. It was found that the latent period in the development of cataract was in inverse ratio to the dosage and that the latent period greatly increased with the age of the animal. They conclude that it is not logical to assume that radiation precipitates a latent tendency for the development of senile cataract. They advance the following reasons for this view point: First, the morphological characteristics differ; secondly, rabbits that develop radiation cataract do not develop senile cataract; and finally, there is a greater susceptibility in younger rabbits for the development of radiation cataract than in older animals.

Upton et al (1953) found that lens opacities could be readily induced in mice by x-radiation, the threshold being somewhat less than 15 r. The opacities increased in severity with the dosage and approached 100% at 33 weeks after exposure to doses of 45 r or more. Cataract did not occur if the head was shielded while the remainder of the body received a radiation of 405 r. In this sense, the process differs from radiation injuries in general.

Alter and Leinfelder (1953) found that when the lens of an albino rabbit is protected from radiation by x-rays, no cataract occurs, even though the ciliary body receives a dose that would be sufficient to produce cataractous changes. Irradiation of the more central segment of the lens in the pupillary zone shows this area to be relatively insensi-

tive, a fact which may be correlated with the slow rate of growth of cells in this area. These writers found that quadrant exposure of a lens would result in a quadrant-shaped opacity, indicating that the cataract is the result of a local irradiation effect.

Cogan and Dreisler (1953) experimented on the minimal amount of x-ray exposure which might cause lenticular opacities in the human eye. They noted that there have been very few quatitative observations on cataract production by x-rays since the introduction of the more accurate roentgen (r) method of measuring dosages. These workers found that no radiation-induced opacities of the lens occurred following a single dose of 400 r in observation periods of six to nine years and also none following a 350 r dosage over a 13 year observation period. Dosages of 600 r produced cataractous effects in one case, while dosages of 800 r produced them in all cases. The cataractous changes as observed by slit-lamp were of the radiation type but did not occur until several years after the irradiation. Cogan and Dreisler conclude that 600 r is a threshold dose for the production of lens opacities in human beings, at least within the periods of their observations.

Duke-Elder offers as a possible explanation for the long latent period for the effect of x-rays, the possibility that radiation has an abiotic effect on the zone of growth of the lens. Histological changes can be found around the equator long before the cataract appears. It is also known that the effect of short wave radiation is most marked on young proliferating cells.

Neutrons and Cataract

Cogan et al (1949) studied the effects of atomic bomb action on the natives of Japan who had been subjected to such bombing. Ten subjects, aged 13 to 55, who had been from 550 to 950 meters from the center of the blast, showed similar types of cataract. In these cataracts, there were opacities in each eye in the axial zone of the posterior capsule in areas of two to four millimeters in diameter. The cataracts were found by slit-lamp to be lace-like in appearance with a few polychromatic crystals and a few vacuoles in the posterior capsule, with no extension to the underlying cortex. The cataracts, in general, were similar to those associated with exposure to x-rays and to gamma rays.

Kimura and Ikui (1951) found that lenticular changes in atomic bomb cataract showed a plano-convex form of posterior polar opacity. The middle one-third of the posterior lens capsule was found to be wrinkled, thickened, loose, and separated from the underlying cortex by a quantity of amorphous debris. There was a clear-cut demarca-

tion between the normal cortex centrally and the peripheral cataractous band.

Treatment of Cataract

Treatment of cataract has been designed either to cause absorption of the opacities or to improve the nutrition and metabolism of the lens, disturbances of which may have produced the opacities. Duke-Elder considers the first approach valueless and mentions the lack of success in the use of iodides, calcium, potassium, and homeopathic remedies, such as small doses of naphthalene, and various types of lens extracts. Systemic treatment of diabetes may have value, however, in halting the progression of diabetic cataract; this type of treatment falling into the second of the two categories listed above. Periodic refraction is indicated and the use of tinted lenses may be suggested. As the final recourse, obviously, operative treatment may be performed.

Gillette (1941) reported that the local use of thyroxin by means of drops inserted into the eye does not check the development of senile lens opacities and does not cause the absorption of lens opacities already present, in spite of claims that had been made to the contrary.

Selinger (1935) obtained no favorable results on cataract by the injection of extracts made from cataractous human lenses. On the other hand, Shropshire (1937) reported favorable results with extracts of fish lens proteins on 100 cataractous patients. He states that after three or more treatments on 83 patients, 71 showed a gain in visual acuity and only 11 showed no change or a loss in v.a. The opacities viewed ophthalmoscopically were said to be reduced in size after treatment. Shropshire says that there is a sulfur-bearing amino acid in fish lens proteins which by its action as an auto-oxidizing agent has therapeutic value. In a later paper, Shropshire t al (1952) again reported favorable results with extracts of fish-lens proteins administered to humans and to rats with experimentally induced cataract. It may be said, however, that Shropshire's work has been open to much criticism, not only on the basis of its lack of validity but also because it may sensitize a patient to specific lens proteins and thus introduce serious complications in a subsequent cataract extraction.

DISCUSSION

Although many theories have been advanced as to the etiology of cataract, no one has so far been universally accepted. However, it is certainly unwise to take a negative attitude in this regard. Thus, some men maintain that chemical studies of the lens are sure to be as futile as chemical analysis of the optic nerve is in Leber's optic atrophy. Accord-

ing to these individuals, heredity is the sole mediating agency. However, heredity itself, as Krause (1940) indicates, is basically chemical and can be changed by man in many instances. For example, although there may be a hereditary tendency toward diabetes, the disease can be controlled after it develops. It is thought by some, however, that progress in chemical research on the aging lens will lag until more is known about senescence, heredity, and biochemistry. It may be asked whether senile cataract is a primary result of senescence or a secondary response to alterations in the body fluids which have not maintained a proper equilibrium in the aging of that person. It is hopeful sign that as the aged become a larger and larger segment of the population, considerable research is being devoted to the problems of aging.

Bellows and Chinn (1941) point out that certainly no single theory can encompass all of the known facts in cataract investigation. They point out the need for more knowledge concerning intracellular respiration so that we can appreciate the importance of a decreased nutrient supply in the pathology of senile cataract. Unnoticed subclinical vitamin deficiencies may be maintained for months or years and initiate irreversible changes in the lens. It is to be hoped that recent rapid biochemical advances, especially in the fields of protein structure and intracellular enzymatic respiration, may afford additional important clues.

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ADAPTING MOTION PICTURE DEVELOPMENTS FOR VISION TRAINING IN OPTOMETRIC PRACTICE*

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Optometry as taught and practiced today devotes much time to the analysis of binocular vision because it is believed that binocular anomalies can result in visual problems and asthenopia. Vision training is one of the means used to alleviate anomalies and problems arising in binocular vision. The training is performed largely with stereoscopes, many of which are almost unrecognizable as decendents of the parlor stereoscope of a half century ago. In addition to the older Wheatstone and Brewster stereoscopes, we are now using anaglyphs, vectographs, and polaroid for direct view and for projection. The later methods enable us to perform some of our investigations and do some of our training work in open space away from the box-like stereoscopes which still remain major tools.

The change in stereoscopic cards and targets from the photographs associated with the "parlor" stereoscope is even greater. There is a wide variety which in general differ from the traditional stereophotographs in one or more of the following attributes: (1) They have control marks or blocked out areas, seen by one eye only. (2) the disparities tend to be large in comparison with the monocular clues provided, so that the stereopsis is exaggerated. (3) they require relatively large amounts of convergence or divergence as a consequence of the disparity. (4) the cards are at least arbitrarily graded into increasing levels of difficulty. (5) the cards may be used out of sequence and for varying durations. This becomes important when we realize that the fixed sequences and durations of cinematic scenes prevent such variation of sequence and time of exposure.

The new screen techniques under discussion include "3D," Cinerama, and CinemaScope. The first is stereoscopic, the others achieve their apparent increase in perceived depth by monocular clues exclusively. The present paper will include an analysis of these new techniques, methods by which they can be applied to training in their

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present form, and some opinions concerning their adaptation to vision training procedures.

AN ANALYSIS OF VISUAL CHARACTERISTICS

Two trends are present in the change from the older type of motion pictures. The first is essentially a wide field picture. The second is stereoscopic. These two trends are not necessarily antagonistic. In fact, under ideal circumstances, the "3D" picture would be presented with as wide a field view as the CinemaScope and Cinerama.

Because "3D" involves some discussion of disparities and vergences a discussion of the characteristics of such films will follow. The basic distance unit is the viewing distance, *i.e.*, the distance of the observer to the screen, and the basic unit of disparity is the ratio of disparity to the "inter-ocular" distance which we normally term the interpupillary distance. By triangulation, using the viewing distance to the screen, and the ratio of the disparity to the interpupillary distance, the relative position of the crossing point of the visual axes can be described (Figure 1). These elements are used in quantifying the apparent

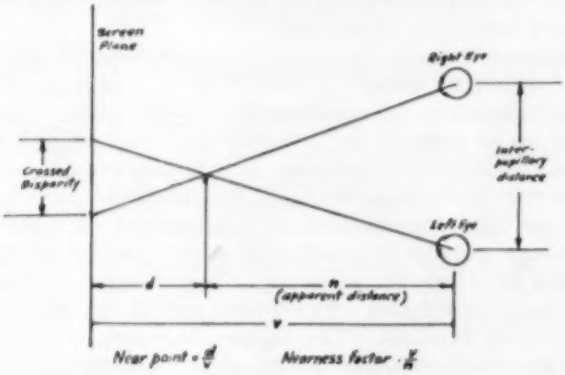

Figure One

nearness of the object in terms of the relationship of the object distance to the viewing distance. Two systems of notation have been developed, one here, the other in England. Both systems are intended to measure convergent disparity: no comparable notational system to cover divergent disparity appears to be necessary or advantageous. The system of notation that we might discuss first is the one used by The Motion Picture Council of Hollywood, California.

In this scheme the screen plane is called the plane of convergence, and the infinity plane the far point. Planes nearer than the plane of

convergence are indicated as decimal equivalents of the ratio of the distance of these planes from the plane of convergence to the distance of the observer from the plane of convergence. Accordingly, a given point may be termed 0.5 or 0.6 near point. In this, a linear system, the relative increase in convergence angle that one meets changing from .07 to .08 near point as compared with changing from 0.0 to 0.1 near point is concealed. To meet this Spottiswoode, Spottiswoode and Smith (1952) have recommended the other, somewhat different system of notation, involving a reciprocal unit called a Nearness factor (N) which is proportional to the convergence required. The Nearness factor can be written as the ratio of the screen distance to the projected distance of the disparate object from the observer. (Consult diagram.) A table of equivalents for those two systems follows:

Disparity on Screen in inches*	"Near Point"	Nearness Factor	Effective Distance to Observer in Feet†
0	0.0	1	50
0.3	0.1	1.1	45
0.6	0.2	1.3	40
1.1	0.3	1.4	35
1.6	0.4	1.7	30
2.5	0.5	2	25
3.7	0.6	2.5	20
5.6	0.7	3.3	15
10.0	0.8	5.0	10
22.5	0.9	10.0	5
00	1.0		0

*Assuming a standard interpupillary distance of 2.5 inches.
†Assuming a standard viewing distance of 50 feet.

On the far side of the screen plane disparities are not as critical because an uncrossed disparity of 2½ inches results in an infinity position for the viewed object. Although most recommendations in the past (Sherman, 1953) have been that no film should use divergence because of its unnaturalness or for some other reason, more recent advice has been that some divergence is permitted. (Bulletin 218, M. P. R. Council.) At 50 feet a disparity of one foot would require only 1.6 prism diopters of absolute divergence for fusion, a figure which is only about 20% of the average divergence ability (of 9△) when tested under standard optometric conditions.

As far as the near point is concerned standard recommendations are to shoot and project most scenes so that the nearest point for most shots comes no closer than 0.5 near point or one-half the viewing distance. In extreme cases it can momentarily be as close as 0.8 near point or 10 feet from the observer. (Bulletin M. P. R. C., p. 9.) Other recommendations have permitted higher maxima: Sherman

(1953): 0.92 near point; Spottiswoode (1952): 0.90 near point; Norling (1935): 0.88 near point. These maxima indicate minimum distances from the observer of 4 feet, 5 feet, and 6 feet respectively. They correspond to convergence requirements of 2△ to 5△, which compares with an average convergence ability of about 20△ under standard refraction room conditions.

The writer sat as a member of the audience at a recently released "3D" film (opened November 25, 1953) "Cease Fire" and made comparisons from a seat in the center of the orchestra, a distance of about 75 feet. Because the projection distance is longer than in most theaters around the country and, therefore, the picture is larger, this is roughly equivalent to the 50 feet viewing distance that is used in many cinema calculations. The various disparities, the part of the scene in coincidence at zero disparity, the position of the stereo-window and very roughly the relationship between apparent size and disparity in any given sequence were observed. The observations can be summarized as follows: (1) The object or area of major interest is normally maintained at the screen without disparity. This includes some shots in which moving objects were followed in a "panning" technique, (2) for long distance shots the area of major interest may lie behind the screen, and possibly require some divergence (the maximum homonomous separation was estimated at about three times the interpupillary distance), (3) for close-ups, occasionally the front of the screen comes up to a near point of 0.6 or 0.7 and for a very few trick shots up to 0.8 or slightly more, (4) stereopsis is apparently used to augment monocular distance cues, especially size constancy since the latter seems to remain the major factors on which the cinema relies for distance judgments. In the most extreme case of nearness observed, the apparent distance from the observer indicated by the apparent size was estimated at half of the distance indicated stereoscopically. (The advice of stereotechnicians to their directors and camera men is to narrow the interaxial separation of the cameras on close-ups to avoid distortion and eye fatigue. This lowers the stereo-nearness factor.) While depth judgments can be made under conditions of physiologic diplopia (Miles, 1949) it is the considered opinion of stereo technicians that the movie audience will not find such situation comfortable.

On the basis of these calculations it can be seen that at a viewing distance of 50 feet (15 meters), about 0.4△ was required for fusion on the screen and that the total range of convergence recommended for normal shots was from 0.0 to 0.8△ of convergence. The maximum divergence used was about 0.8△ base-in, and the most extreme convergence was 2.0△ base-out, (the recommended maxima reached 5.0△).

Certainly one meter angle will constitute an extreme of vergence in present techniques. However, since the values used depend more on artistry and public acceptance than they do on science, they may change momentarily. This range of disparity is disappointingly small for our purposes, particularly when one considers the standard training stereographs we use, in which the angular disparity may reach 10△.

The other new projection techniques are nonstereoscopic. Distance appreciation is on the basis of monocular clues. Since the wide field of view increases the number and intensity of such clues, the apparent depth of the picture is enhanced. Two other factors are worthy of consideration. They are: (1) The number of films available for such purposes. A recent daily newspaper in a special supplement devoted to a preview of the motion pictures of the coming season (1953-54) anticipates that out of the 80 scheduled pictures 10 will be in "3D" and approximately 20 in other forms of wide field flat film cinema. (Cameron, 1953.) (2) The second factor is that of expense. These movies probably average from $0.75 to $2 per viewing depending upon the hour of attendance and the scale of the theater in which they are shown. These factors of a small number of available films, and the expense involved may act against the use of "3D" films for training purposes.

"3D" AND WIDE FIELD CINEMATIC DEVELOPMENTS IN VISION TRAINING

Five training problems come to mind in which these new techniques can be applied. They are:

(1) Amblyopia.
(2) Suppression and faulty fusion.
(3) The development of stereo-awareness, range and acuity.
(4) The development or improvement of vergence.
(5) Increasing the width of the zone of clear single binocular vision.

(1) *Amblyopia.* For this purpose the monocular clue provided by the nonstereoscopic techniques may prove beneficial particularly if they are in color. This would require that the patient go to the cinema with the better eye occluded in order that he be forced to use the amblyopic eye and develop its vision. The presence of action in the periphery and the wide field may develop better acuity and better fixation ability. This hypothesis along with those following will require case study for documentation.

(2) *Suppression and faulty fusion.* Most techniques for eliminating suppression and developing a better sense of fusion commence work at the vergence angle of easiest fusion. In severe cases of suppression

the target illumination may be varied if differences with relative brightness of the targets reduces the tendency for suppression.

In order to apply these techniques to the available "3D" pictures, as many as 4 components may be required before each eye: the spherocylinder correction, relieving prisms, an absorption filter and the polaroid filters. Feinbloom (1953) has recommended the use of a specially prepared doublet designed to include the correction, the prisms and the polaroid filter. However, a clip-on with interchangable toric prisms should serve. The prisms may be round in order to use them at different positions. There are devices available which can be used as a substitute for the prisms. One consists of two opposing and variably positioned mirrors which can be set so that a given amount of vergence is needed for fusion. This is mounted on a handle so it can be conveniently held in the hand.

The absorption filters need not be made of glass; they can be prepared from photographic film exposed for varying durations, or obtained as commercially available gelatin or film filters. An alternative method of obtaining absorption for one eye would be to place a piece of polaroid *behind* the polaroid of the viewing spectacles and to rotate the former until the desired degree of absorption is obtained.

The problem of quantifying the absorption filter is a more difficult one since it is possible that in any given individual the amount of absorption needed to eliminate suppression may have the over-all level of illumination as one of its parameters.

If we ignore this factor of level of illumination, there are two methods available for determining the amount of absorption needed. Differential intensity affects simultaneous binocular vision and also stereopsis, and therefore, either effect can be used to regulate the differential intensity.

The first method would involve the use of direct view or projected vectographs containing control markings. Various filters would be introduced until that one is found which most frequently gave equal visibility of the control marks. This method of determination would require less transfer than variation of illumination while viewing a stereoscopic target or slide in an amblyoscope or stereoscope. This second method involves the effect of differential intensity or stereopsis.

Verhoeff (1933) set up a stereoscope in which each eye viewed a black line (on a white background) inclined outward at the top, to an equal extent. The appearance to the observer was of a vertical line whose upper end was further away than the lower. If a filter was introduced before an eye the line appeared to incline toward the opposite

eye but with a reduced stereo effect. Verhoeff describes this effect of absorption as an apparent reduction in the disparity of the line seen by the eye with the filter. This phenomenon can be utilized here by introducing two inclined vertical lines (or sticks) in a stereoscope and varying filters until the fused image does not incline to the right or to the left.

Verhoeff (1933) found that at 64 ft. candles an 80% absorption filter before one eye resulted in about 20% reduction in the disparity and a 98% absorption in about a 1/3 reduction in the disparity. The movie producers are keenly aware of the effect of differential intensity in "3D" on viewer comfort, and make every effort to equalize the intensity of the two views. McCulloch and Crush (1946) found that a decrease in stereoacuity accompanied suppression. Probably the three factors of stereoacuity, suppression and differential brightness are all related as indicated in a study by Miles (1953). Norling (in Quigley, p. 36, 1953) recommends equality of intensity of the 2 views to within ¼ of a lens stop for color views (that is to within about ±25%) in order to avoid discomfort, and loss of stereopsis.

(3) *Development of Stereo-Awareness, Acuity, and Range*

There exist patients who have simultaneous vision and fusion but who do not exhibit stereopsis. Such patients are not common, but the writer has learned of one instance where an individual may have obtained stereopsis for the first time while viewing a "3D" colored movie. In this situation all of the factors make for realism (Gunzberg, 1953).

The development of stereoacuity has been one of the goals of vision training for some years; and Walls (1952) has pointed out the desirability of increased range of stereopsis. However, the presence of depth awareness or stereopsis need not imply fusion as depth judgments can be made on the basis of the physiologic diplopia (Miles, 1949). Murroughs (1953) recommends the use of "3D" movies without relieving prisms if it can be established that in the observer the eyes are straight and a desirable binocular pattern is present. Nevertheless, present day "3D" is not designed to develop stereopsis range or acuity.

(4) *Development and Improvement of Vergence.*

As indicated earlier the change in vergence in viewing "3D" rarely amounts to more than a few prism diopters. Therefore, when vergence training is specified, the increased vergence must be obtained by the adaptation of prisms or by the use of a special device. In severe cases, like tropias in which the patient cannot properly maintain fusion at the viewing distance, some relieving prism power may be necessary

(Brock, 1953). But when fusion can be maintained at this distance, increasing amounts of "exercising prisms" can be utilized as long as the patient can maintain fusion and stereopsis. It is probable that fusional reserves will be greater while observing "3D" movies than under standard examining conditions since a recent European study (Popkowski, 1950) indicated that they will increase 44% when taken on stereoscopic motion pictures rather than immobile ones.

(5) *Widening the Zone of Clear Single Binocular Vision*

Those patients who obtain single binocular vision as a consequence of inappropriate levels of accommodation, will have blurred vision. This accommodative convergence can often be replaced by fusional convergence by orthoptic training, with the result that the binocular vision becomes clear. When this occurs while viewing "3D" movies, appropriate spherical powers can be added so that vision is clear, and then gradually reduced. By this method vision is more likely to remain binocular.

SUMMARY

There will be only ten "3D" movies shown in the U. S. A. this year. The chief advantage of this medium for training is the added motivation. The disadvantages lie in the cumbersome viewing apparatus needed, the ungraded order of difficulty of the views, the relatively low magnitudes of vergences and disparities and the absence of controls. Under these circumstances, it is this writer's opinion, at present, that on the whole they may not be so much more valuable than the educational "3D" viewers for stills that are readily available for home use. They are more likely to have utility for some purposes like developing vergence than for others like eliminating suppression.

On the other hand, a visit to the "3D" cinema made obvious the fact that we tend not to use "monocular cues" in our offices to the degree that we might. For example while increasing induction by means of prisms or decreased separation in the stereoscope, objects appear smaller. If we used arrangements in which the object was made simultaneously larger to offset this effect it is likely that the increased apparent nearness of the image would increase the convergence ability.

DESIGNING "3D" EQUIPMENT AND FILMS FOR OFFICE USE

At the present time there is at least one series of conferences under way regarding the manufacture of "3D" equipment and films for vision testing and training. To summarize the criticisms given earlier in this paper so that they can be considered in designing any new devices for these purposed, we can include:

A. Equipment: Cameras to be paired with control of illumina-

tion and overlap. Various focal length lenses to control magnification without excessive change in viewing distance. Cameras to be adaptable to film strips as well as cinema. Arrangements to change films readily should be included. Screen to be curved to aid in projecting with large overlaps.

B. Films: Preferably in color. Drawings (Disney type) as acceptable as scene. Film length approximately 15 minutes to one-half hour. Graded material in separate films extending from one for simultaneous binocular vision training up to one for large disparity changes and other of fine stereoacuity. Control marks nearly constantly in evidence.

On this basis it seems probable that office movies, which can also be used at home, when properly designed will be more effective than present day "3D" cinema, very much in the same vein as our present training slides appear more effective for training than the stereophotographs of two generations ago.

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THE DESIGN AND DEVELOPMENT OF A CONTACT LENS FOR UNDERWATER SEEING*

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HISTORY

Although not directly related to the subject, something of the history[1] and uses of contact lenses should be quickly reviewed. The first contact lens was used by Thomas Young in 1801. This device, merely a water cup to eliminate the cornea as a refracting surface, was utilized only in measurements concerning the process of accommodation. Young found that whether the lens was used or not, the range of accommodation was the same, demonstrating conclusively that the cornea was not concerned with the accommodative function.

In chronological order, the next lens of importance was one proposed by Sir John Herschel in 1827. Sir John, an astronomer, did not actually make his lens, but suggested the use of a lens to cover the front surface of the eye and restore a spherical surface to badly distorted corneas in astigmatism and keratoconus.

In 1887 F. E. Muller fitted himself with the first blown contact lens. Its function was that of protection since his lids and one eye had been removed because of cancer.

Then, in 1888, A. E. Fick fitted a blown lens to a patient who had keratoconus. Fick suggested the term "Contact lens" and also described the effect of the Sattler's veil or the Fick Phenomenon.

Henri Dor, in 1892, suggested the use of physiological saline solution instead of distilled water, as previously used, between the cornea and the back of the surface of the lens.

The next major step was not to come in this field until 1929 when Carl Zeiss brought out the first fitting set of contact lenses. The mechanical fitting problems were somewhat reduced but as yet far from modern standards.

The modern era of contact lens work began in the 1930's. In 1932

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Joseph Dallos produced the first focal contact lenses after experimenting with impressions of the living eye using Negocoll. Then in 1935 the Muller-Welt lenses were introduced commercially and in 1938 Obrig brought out the molded plastic lenses.

Other advancements made in this field were the Feinbloom conical contact lenses and the Solex and Para-curve corneal lenses all being introduced in the late 1940's.

Fitting procedures and knowledge of the effects produced by contact lenses increased rapidly and in the early 1950's new developments in the field of contact lenses were forthcoming with the introduction of the scleral fluidless types of lenses. The contact lens specifically designed for underwater seeing as developed by Monical and Nagel was an adaptation of the scleral fluidless type—specifically the Butterfield Para-Scleral.

USES OF CONTACT LENSES

Contact lenses currently perform three major functions:

(1) to aid vision
(2) to improve the cosmetic appearance by
    (a) camouflaging unsightly corneal scars or deformities
    (b) ridding the patient of unattractive spectacle lenses
(3) to protect the eye from
    (a) injury
    (b) disease

We now propose a fourth use of contact lenses: *Sight Under Water*. This of course is a restricted and specialized use of the contact lens, yet is practical and beneficial to certain interested parties.

PROBLEMS ENCOUNTERED

As is known, the eye derives its refractive power (about +59.00 diopters)[2] from two major sources, the cornea and the crystalline lens. In comparison, the cornea contributes approximately +43.00 diopters or more than twice the amount contributed by the lens. Since the index of refraction of the cornea and tears is approximately the same as the index of water, 1.336, if the eye is immersed in water it will loose about 43.00 diopters of its refractive power. To be more specific, underwater, the eye becomes approximately 43.00 diopters hyperopic. Of course, visual acuity is markedly reduced under such circumstances.

While graduate students at the University of California School of Optometry the authors became acquainted with Dr. Hugh Bradner, a research nuclear physicist at the University's atomic radiation laboratory and, incidentally, a member of the National Research Council on Underwater Warfare. Dr. Bradner posed this question, "Would it be

possible to make a single contact lens to provide good vision both above and below the water?"

Of course, a flat faceplate has been a necessity for all sharp underwater seeing, and has accomplished this quite well, but is subject to many defects. A face plate is a mask with a flat, transparent front surface. It fits snugly around the head, over the brow and below the nose. Thus, an air space is created between the eyes and the object of regard.

SOLUTION

The lens, see Figures 1 to 7, which the authors constructed to solve this problem is simple. It consists of a transparent cone with a flat front surface attached to an ordinary para-scleral contact lens manu-

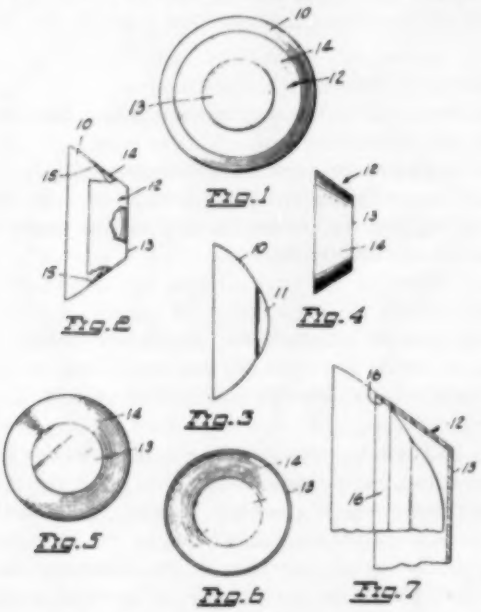

Fig. 1. Top view of the assembled "Underwater Lens." Fig. 2. Side view of the assembled "Underwater Lens" with the cone, or cap, shown in a cut-away section. Fig. 3. Side view of the external portions of the basic contact lens. Fig. 4. Side view of the cone. Fig. 5, and Fig. 6, top and bottom views of the cone. Fig. 7. Detailed cross sectional view of the assembled "Underwater Lens" showing the cone and its attachment to the basic contact lens.

Explanation of the figures shown in the illustration: #10. The scleral portion of the basic contact lens. #11. The corneal section of the basic contact lens. (Powering is introduced here.) #12. The cone or cap. #13. The optically flat front surface of the cone. #14. The "side" of the cone. #15-16. Points of attachment of the cap and the basic contact lens.

factured by George H. Butterfield and Son, Portland, Oregon. It is a minimal clearance scleral type contact lens with two raised "Islands" on its inner surface. The lens is made in a number of scleral forms, however three of these will fit approximately 80 per cent of all individuals, thus simplifying the fitting problems.

The outside scleral portions of these lenses are symmetrical so that a cone may be placed over the front of the lens and there will be a ring of tangency between the cone and the lens.

This was done, using a plexiglass cone with a flat surface. When in place, the cone, or cap, is cemented to the basic contact lens. The flat front surface of the cap is exactly tangent to the front of the basic lens so as to add strength and reduce the overall thickness of the lens. Thus, an air space of minimal thickness is created between the cone and the contact lens. The object space effectively becomes an air space and not a water space so that normal acuity may be obtained above and below water.

Strength and thickness are very important factors when considering underwater lenses as swimmers, such as frogmen, may work at depths of 100 feet or more where the pressure is approximately 45 pounds per square inch in excess of normal atmospheric pressure.[3] Since this is about equivalent to three atmospheres pressure, the lens must be strong enough to prevent warping and distortion of its surfaces while under water. Warping the front surface would lower the visual acuity and would tend to weaken the lens so that it might possibly break while being worn, resulting in injury to the eye. One of the toughest hurdles for the contact lens patient is lid sensation. However, the increased thickness due to the addition of the cone and flat surface is of little consequence as the lens is worn for relatively short periods, and while underwater the lid sensation is greatly reduced. For all of its "space man" appearance, the lens is remarkably comfortable.

SUMMARY AND DISCUSSION

Since the largest outlet for these lenses will probably be the Navy Department of Underwater Warfare it is appropriate to discuss the advantages of this lens and fitting procedures in the same portion of this paper:

(1) The lens will not "fog," due to condensation, in any temperature of water, where faceplates tend to fog materially as the temperature is decreased.

(2) The contact lens does furnish a larger peripheral field of vision than that given by a faceplate. This is of importance in sensing obstacles or living dangers and charting underwater terrain.

(3) They do not leak nor fill with water. This could be particularly bothersome with a faceplate if the swimmer were performing an exacting task such as working on a mine.

(4) The contact lens, as opposed to faceplates, does not become dislodged if the swimmer is hit by a wave or if he enters the water from a fast moving boat.

(5) The lenses are not obvious from a distance, as are face masks, a possible factor of importance for some espionage tasks.

(6) The lenses make it easier for a diver to clear his ears and relieve pressure sensations by pinching his nose during descent. Many styles of faceplates cover the nose and prevent this helpful procedure.

(7) Wearing time is not of major importance since three or four hours is the maximum time required for these lenses to be worn. This may be easily accomplished.

(8) Maximum visual activity is obtained both above or below water with the new contact lens. A refractive correction, if any, may be incorporated.

We hope these lenses will not be used exclusively by frogmen. It is hoped that the scope of their use may soon extend beyond the military.

The lenses are fitted exactly as any other scleral contact lens would be. The visual examination is made with the patient wearing the contact lens and then the lenses are sent for powering. The cap is attached after fitting and powering.

At the present time only the para-scleral lenses are used as this procedure reduces fitting problems to a minimum, which is very important to military operations.

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THE ANNUAL MEETING

The profession must receive a rather peculiar view of the activities of the American Academy of Optometry when they read reports and accounts of an Annual Academy Meeting. The Academy meets each year, yet, from press reports, it never seems to discuss certain important matters which are essential to our well being as optometrists. For instance, the Academy itself never discusses money. The economic activities, as these relate to payment to optometrists for work done by them are not discussed. Nor is much, if any time devoted to legislative and optometric-sociological aspects of our work as these apply to public or private health programs, or to variances of professional privileges and

conduct of optometric practice. And, as the domestic organizational problems of the Academy are few, these are—for the greater part—left to the Executive Council to solve. Consequently, the reports of Academy meetings deal largely with clinical and scientific subjects, and these occupy nearly all of the time devoted to an annual meeting.

At times the Academy is criticised for not spending more of its time on these other matters, but it should be remembered that the Academy is chiefly interested in several things. These are better visual science through a fuller understanding of the basic sciences underlying our work. The Academy strives for improved training and educational facilities for the undergraduate student of our professional courses, and for better post-graduate training for optometrists already in practice. It also stands for a high plane of optometric practice through proper standards of work and ethical concepts of practice on the part of every individual optometrist. And, too, the Academy properly feels that it is the job of the American Optometric Association to set the policy on those optometric economic and legislative matters not usually found on Academy agendas. Here, however, the Academy stands ready at all times to work in close harmony with A.O.A. officers and committees in studying problems in these areas, and its members have done much of this.

What then does happen at an annual meeting of the Academy? These annual meetings, of which 33 have now been held, follow to a great degree a set pattern. They conform to a common curriculum—yet each annual meeting is different from the others.

The Academy meets for four days. An individual registration fee of $15.00 covers all costs, including a ticket to the Annual Round Table Banquet. Each day's program starts at 9:00 A. M. At this time each of the five Academy sections, the Section on Aniesikonia; Section on Contact Lens Fitting; Section on Orthoptics; Section on Occupational Optometry and Section on Pathology has a separate meeting, lasting from 9:00 A. M. to 11:00 A. M. During this period on each day, members and guests are free to attend whatever Section meeting they wish. The Section Chairmen arrange different clinical and discussion programs for each day, and those particularly interested in only one speciality may devote each of the days to one Section's meetings. Others will attend one Section meeting on the first day, and another Section meeting on the next. Each Section meeting is open to any member or guest. It is at these Section meetings that the practical aspects of recommended techniques are discussed. Qualified specialists lead these discussion periods, and it is here that Case Reports are usually presented. These meetings are "forums" which are greatly

enjoyed and looked forward to by all members. They satisfy a very proper demand for practical clinical discussion.

At 11:15 A. M. all members and guests assemble in the general meeting hall where the Chairman of the Papers and Program Committee introduces the first formal lecture of the day. As time is limited papers are restricted to 30 minutes reading time, and each paper is followed by a discussion period. Most Academy papers are presented with the aid of slides or film and for accuracy all papers are read. All papers must be approved by the Committee before being presented.

At 1:30 P. M. those attending the meeting again assemble in the general meeting hall where many other papers are presented and discussed until 10:00 P. M. with but a short dinner recess. During the four day Academy program many such papers will be presented—each paper the result of original work, written and read by an optometric authority on one of the aspects of visual or other related science or by an optometrist who has made a special study of some phase of refractive care. It is here that fundamental optometric research is first presented,—research necessary to qualify optometry as a learned profession. It is here that theories dealing with optometric science are first read and discussed before a competent and critical audience. These original papers will later be presented to the profession through the pages of this JOURNAL to take their places in the scientific literature of the day. To arrange, plan and carry out these important sessions is one of the major activities of the Academy and in so doing the Academy makes a contribution not only to the profession itself, but also to all health sciences.

During one of the noon-day recess periods a luncheon is held to receive Local Chapter Reports and discuss Chapter problems. The Chairman of the Committee on Charters and Chapters presides at this meeting. All members and guests are welcome and most of those present at the meeting attend, many with their wives.

The business session of the Academy is usually held from 4:00 to 5:00 P. M. preceding the Annual Round Table Banquet. Committee reports are presented at this session, a future meeting place selected, and officers and members of the Executive Council are elected.

The annual banquet is usually held in the evening of the third day of the meeting. Most members and guests wear dinner coats, although this is not obligatory. The women, too, dress for this occasion. The banquet is preceded by a cocktail hour. Representatives of optometry's official bodies are at the head table, and the Academy President presides. It is here that the guest of honor speaks. On most occasions his talk is formal and of a scientific nature.

From the foregoing, it is evident that during this four-day meeting period, the time of those in attendance is well filled. Members and guests find some important educational event scheduled for every moment. This is the educational opportunity of the year, and the Academy makes the most of it.

Planned shopping, sight-seeing and entertainment should precede or follow the meeting itself. There is simply no time for these things during Academy sessions. Many members arrive a day or two early or stay over a few days to visit, shop and see the sights in the convention city. As this is always a December meeting, the shops are filled with Christmas gifts and shopping away from home adds thrills to the trip, as well as providing an excellent opportunity for selecting unique Christmas gifts. This year, in Toronto, the thrill of shopping in Canada should be hard to resist—and no one should. Toronto is an immense city with many excellent stores, and many places of significant interest to visit.

Academy members are expected to attend this meeting, and many will do so. All are urged to bring optometric guests, particularly applicants and those practitioners now considering applying for Fellowship. Our Canadian members will also have many guests at Toronto, representing the nine Canadian Provincial Optometric Associations, and these special Canadian guests will be most welcome.

If you have not already done so—this is the time to plan the trip. Make arrangements now to come to Toronto, Canada, December 11-14, 1954. The Academy will meet at the Royal York Hotel. For hotel reservations, send your letter direct to the hotel. As space will be at a premium, plan to double up as most rooms at the Royal York are large twin-bed rooms.

Dr. Meredith W. Morgan, Jr., president of the Academy, extends to all members and guests a cordial invitation to come to the 34th annual meeting, and he particularly urges all Academy members to be present.

CAREL C. KOCH

PROFESSOR BARTLEY COMMENTS ON OPTOMETRY

In this issue, we publish a stimulating paper from an authority in an allied field. This paper allows optometry to see itself as another professional man sees it. The paper is written by Professor S. Howard Bartley, Department of Psychology, Michigan State College. It is entitled "The Effectiveness of Therapeutic Procedures as Dependent Upon the Rationale Underlying Them." It follows as a SPECIAL REPORT.

We do not believe the paper by Professor Bartley expresses the general thinking of optometry nor of the Academy. We are not in agreement with certain of the author's points. Professor Bartley seems unduly critical of allopathic medicine. While his criticism may apply to some allopathic physicians, we do not think the philosophy which he attributes to the group as a whole applies. We find his references to visual training overlooking important physiological factors, but this is true no doubt because he is a psychologist and naturaly uses a psychological approach. As Professor Bartley says, his description of the profession certainly applies to sizable elements within optometry, and in this we agree.

While optometrists will find certain things with which to disagree, they cannot help but find Professor Bartley's evaluation conductive to much serious study dealing with self-evaluation and with the possible techniques and approaches to be used by optometrists in the future. Professor Bartley is an outstanding psychologist, and his views are important and are of interest not only to optometrists but to all those interested in vision. We feel this paper will provoke much discussion which will be of value to us all.

CAREL C. KOCH

SPECIAL REPORT

THE EFFECTIVENESS OF THERAPEUTIC PROCEDURES AS DEPENDENT UPON THE RATIONALE UNDERLYING THEM*

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A coherent and comprehensive rationale even for practical procedures is very helpful. The relevancy of this to the healing arts was brought out a few years ago by Korr,[3] in describing the differences between allopathic and osteopathic medicines. He indicated that allopathic medicine was not a clearly defined system and lacked an appro-

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priate philosophy with regard to disease. The osteopathic position, on the other hand, was described as being a set of interrelated ideas forming a systematic outlook on human biology and the troubles that the physician is called upon to alleviate. Regardless of whether Korr was correct in denying the existence of a system in allopathy, he did aptly describe allopathy's shortcomings.

It occurred to me that Korr's comparison might have a parallel in the case of optometry and its allopathic correlate, ophthalmology. Despite any success in drawing a complete parallel, such an attempt would carry a lesson for optometry. The apparent parallel for optometry is based upon the assumption that optometry is an introspective profession ever examining itself regarding its mission and how it may develop an understanding of vision beyond that achieved by any other group. This description of optometry certainly applies to sizeable elements within optometry and it is these we have in mind when we refer to optometry. Visual care taught and practiced by these leaders has little resemblance to the teachings and practice of ophthalmology with its preoccupation with pathology and surgery. The two forms of eye-care are quite separate in some of their objectives.

For us to draw a picture such as Korr did, we must first hear what he had to say about allopathy and osteopathy. His description ran somewhat as follows. Allopathic medicine is a profession that has long been occupied with the *end-results* of disease. It comes into play when the symptoms become alarming to the patient. We could add that, before major "objective" symptoms appear, the physician treats the matter as only being in the patient's head. The patient is told to forget the matter for there is nothing wrong.

This preoccupation with end-results has gone hand-in-hand with the idea of producing effects *opposite* to those of the etiological agent. The application of opposites is the procedure from which the term allopathic originally took its name. The notion of opposites blossomed in the days of medicine's initial concern with exogenous agents such as microbes and bacteria. The function of the physician was to prevent the access of the invader to the human body, or to remove its effects as soon as possible. The former was one of the steps in preventative medicine. The principle of opposition is carried out in various ways. If blood pressure is high, something is done as directly as possible to lower it; if weight is excessive, something is done as directly as possible to lower it; if the appetite is poor, it is directly stimulated; if an endocrine gland is overactive, it is medicated or part of it is removed to reduce its output; if some gland is underactive, it is stimulated or some of the gland's products are supplied to the body. If any of these measures fail,

then the physician must restrict the patient's activity so that he may live within his limited physical resources.

Once the preoccupation with symptoms has taken over, concern with the *differences* in diseases rather than with their common features becomes primary. The most highly regarded of the medical arts, for example, is *differential diagnosis*. Differential diagnosis is the search for a label for a given constellation of signs and symptoms from which to reason back to some supposed etiological agent. Medicine finds itself at a loss to carry on therapy until a satisfactory label is found. We might add parenthetically here that the present-day tendency to blindly administer the newer drugs without diagnosis is probably reversing this practice to some extent. Be that as it may, this practice is neither good allopathy nor osteopathy. It is simply a glorified usage of panaceas, once decried by medicine as an "old wive's" practice.

When the symptoms are learned, then attention is focused upon the possible etiological agent or its effect. Two therapeutic alternatives stem from this: (1) The attempt to remove the pathogenic agent (or block its action). (2) Failing to identify or remove the pathogen, the application of agents or measures calculated to produce *opposite* effects.

Among other things, Korr pointed out that what is a pathogenic agent and what is not is often dependent upon the reaction of the organism rather than upon fixed intrinsic properties of the agent. He also emphasized that to him allopathic procedures are measures taken "after the horse has been stolen." In many cases, when the signs and symptoms appear, the disease process is so far advanced as to be irreversible. This is true of a large body of diseases that are classed as degenerative. The practice of the allopathic physician is reduced to "relieving, repairing and removing." The common practice of confusing what is cause and what is effect is inherent in the search for the etiological agent. This is true in the case of diabetes mellitus, when it is said that the disease is *caused* by pancreatic insufficiency. Pancreatic insufficiency is close to being a terminal link in a long chain of processes. As another instance, rheumatoid arthritis is imputed to a metabolic anomaly in connection with adrenocortical insufficiency. Actually, the insufficiency is itself one of the results of a complicated disease process that may have had its beginning many years prior to the emergence of any disturbing symptoms.

This description of allopathic medicine may evoke no surprise, for it is the description of the only kind of therapy that most persons have ever known, or seriously thought about. It just represents standard medical thinking. Its short comings do become apparent with a little

further consideration. It may be obvious that medical practice is often more concerned with the disease than the patient. Disease-centered thinking is so commonplace as to preclude most people's thinking about any other form of therapy.

Centering on disease is inadvertently a sidestepping of the direct pursuit of understanding the physiology of the human organism. The newest preoccupation with fighting disease is the form in which the direct battle between pathogen and antibiotic is waged within the human body, but with the organism as supposedly the *passive* test-tube for it all. In many such cases, the symptoms of the disease are alleviated only to find that the patient could not stand the battle. He has developed a new set of symptoms, the side reactions. These indicate the impossibility of assuming that the patient can be physiologically passive.

For another and unusual way in which one of the same diseases has been treated, read Korr[4] in which he describes a treatment for pneumonia not directed against the pathogen at all.

Korr's description of osteopathic strategy runs something like this:

1. Disease is not synonymous with, characteristic of, or even determined by the pathogenic agent. Disease is rather the response of the individual to the *stimulus* of the pathogenic agent. Actually, the distinction between pathogenic and non-pathogenic agents is not fixed, but is determined in many instances by the response of the individual human organism. A fully normal stimulus to one person may elicit a *disease response* in another.

2. Complex man can respond only in a limited number of ways. These are determined by his nature rather than that of the "pathogenic agent." The central aim of the osteopathic physician is to understand the patterns of responses of humans in general, and the patient in particular. The procedure is to alter response in a favorable direction and prevent unfavorable response. The study of disease becomes the study of man.

Osteopathy is not just a form of therapy but instead is a broad biological philosophy to guide outlook and practices regarding health and disease. It actually is a compensation for allopathic medicine which, by its strategy, is sparing man early death by infectious disease, only to have him linger and succumb much later to the misery and disablement of chronic degenerative disease.

3. The osteopathic lesion as disclosed by palpatory and other present-day clinical criteria is the *somatic* component of a basic general disease process organized in its initial stages by the central nervous system. The potential or actual character of manifestation of the process

("the disease") is determined not by the etiological agent but by its *locus*—the level of the nervous system involved.

4. The rate of progress of this process and the fullness of its manifestation are influenced by factors pertaining to the organism such as constitution, age, previous history, nutritional state, etc.

5. The same process may be set up in various ways. According to osteopathy, it is most usually initiated in the somatic or myofacio-skeletal structures through postural stress.[4] A postural stress is then a decisive promotional or probability-increasing factor in disease. It predisposes the involved segments of the body and thus the whole individual to the action of stimuli, noxious or otherwise. It exaggerates responses to those stimuli.

Now, what has this contrast between two therapeutic philosophies to do with optometry?

The professions of optometry and ophthalmology, and the pure science of vision all have had a common heritage in some respects. Ophthalmology is a part of allopathic medicine and partakes of its characteristics. Optometry is such as to merit a different description. In light of this, two things might be expected: (1) In so far as the two professions have had the common heritage just alluded to, they might be expected to be alike; (2) inasmuch as one is a part of allopathic medicine and the other is not, they would be expected to differ. However, the differences expected from these backgrounds are only the beginning of a further dissimilarity, for optometry, through the work of some of its practitioners, has set out on a road not taken by ophthalmology. Optometry is a self-critical profession, an arch promoter of every move to understand vision as a human performance rather than to deal with eyes as local organs that can be medicated and excised. Ophthalmology, on the other hand, has busied itself with eye-care and localized ocular therapy. When anything is to be done about the broader features of human performance involving vision, it is left to some other specialty.

Inasmuch as Korr did not point out the traits of allopathy specific to ophthalmology, it is necessary for us to isolate them. If allopathic rationale had shortcomings, they might be expected to pertain to ophthalmology as well as to the more common forms of medicine.

The ophthalmological viewpoint in regard to vision is essentially as follows. Vision is a performance which relates the individual to the world around him through the eye, an optical mechanism that forms a representation of selected portions of this world from moment to moment. This representation is sent to the central nervous system, and, if standard, is used appropriately by the nervous system. As a

consequence, experience and behavior are everything that is expected of them. They are normal and satisfactory. Treatment of defective vision lies solely in detecting localized malfunction and compensating for it by artificial means. The most usual etiological factor is the optical condition of the eye itself, through some intrinsic change or through some invading pathogen. The therapist examines the eye to determine its departure from standards of normality. The assumption is that when tissue pathology is treated and compensations via eyeglasses are supplied, the therapist's job is concluded. Although it is sometimes admitted that people fail to behave in a manner expected from the optical behavior of the eye, this is glossed over as a possible "psychological problem." In such cases no effort is made to bring this problem into the domain of the therapist's understanding and responsibility. Coping with the "psychological problem" is left to the patient or someone else.

This general viewpoint insists that training of vision is impossible except to the extent that the patient can be helped to become a more careful or skillful "observer." This is a homespun notion and improvement is generally left to the patient himself, who seldom or never accomplishes it. Any professional man who systematically does something to bring about visual improvement by training is looked upon as a quack because care of eyes and formalized learning to see more efficiently are thought to have no connection. Anyone so unconventional as to consider these as part of one broad therapeutic responsibility is thought to be either ignorant or unscrupulous.

One reason the ophthalmologists look with grave suspicion and doubt upon doing anything other than prescribing glasses and performing surgery for visual troubles is that they expect to do nothing until indubitable symptomatology shows up, and, then, true to the allopathic outlook, reversal of performance is thought unlikely or impossible. Ophthalmology never suspects that something about visual care can precede gross symptomatology.

The medical view holds that virtually every hoped-for remedial procedure within the organism is to no avail in vision for the trouble is believed to be structurally (anatomically) determined. There is nothing to do for myopia, for example, but to put eyeglasses on the patient. No training procedure is of any use; vision is not a learned affair and inefficient habits cannot be unlearned. There just are not any habits to be considered; the behavior is purely reflexive. Eyeglasses and surgery are the only aids for optical and motor anomalies. It is argued that experience supports only this view. This much we can say. Anyone with this view is stopped in his tracks. His view precludes experimenta-

tion aimed at trying to alter organismic function. If we all held this view, we should never come to know just how much improvement might be accomplished by training.

There is a doctrine (not in ophthalmology) that there are three stages in the changes that take place in the organism: (1) An immediate functional adjustment to the initial change in demand of the environment upon the organism; (2) a stereotyped response (habit) to a sustained demand, and (3) an anatomical change to still more prolonged demand. In the light of this, if only marked symptomatology is used as a basis for concern, then it is likely that conventional therapy, be it ophthalmological or optometric, will be given over almost exclusively to changes that do have a demonstrable anatomical basis. If so, then the argument of whether visual anomalies can be reversed is beside the point, after all. The situation is "rigged" so as to determine the answer. In such a situation, the allopathic contestant will win the argument, since the cases under discussion will really be those in which anatomical irreversibility is demonstrable.

Possibly, extensive practice of preventative therapy is some distance off, but he who practices "corrective" or compensatory therapy for ocular anomalies would become effective in more situations were he to include preventative considerations in his thinking. At least it can be said that the negativist is not the one to look to for possible advancement in our understanding of anything. He is not the one to be believed in regard to just what can or cannot be done in the direction of therapy.

We turn now from allopathic thinking to optometry. Many optometrists recognize that the individual is brought into contact with the world around him via an optical system which must not be greatly defective else the visual end-result will suffer. This view asserts from the very start that the seeing process is a performance which involves active participation of other than optical mechanisms and oculomotor processes for its accomplishment. It is taken to be the domain of the visual therapist to be concerned with these collateral processes and mechanisms in so far as they are involved in visual performance, for these men believe, it is the only way to deal with vision as such.

These optometrists examine the patient by refraction-determining instruments, but not simply to see how the eyes deviate from some fixed standard of normality. The objective is to use the findings in determining what it is that the patient is trying to do visually. To these optometrists it is clear that they are dealing with a patient rather than a localized entity such as a "disease" or a peripheral defect. The strategy of such therapists is not to cure a disease or simply compensate

for an organ defect but to help restructure a patient's visual behavior. Once these optometric therapists ascertain what the patient is doing, how he "structures space world," then they can set about to give some assistance. This assistance is directed toward making visual behavior more efficient and more comfortable. The two phases of the task are by no means synonymous.

This modern optometric view not only leaves the door open for possible manipulation of organismic functioning but actively attempts it. While this view is young and has had neither time nor sufficient application to indicate unqualified success, it gives indication of becoming successful.

Put in slightly different terms, the rationale of these optometrists could well be stated as follows:

1. Malfunction is to be understood in terms of the organism's response to the environment around it.

2. The environment itself is in a way determined by the organism: *i.e.*, the organism's response is a form of its own interpretation of what it has to cope with (the environment).

3. The commonly understood "disease process" (manifest dysfunction) is but a tangible stage or end-result in a more prolonged set of changes of response which must be understood as a whole. That is, it must be seen in terms of principles which apply to all stages in the sequence.

4. The optometric therapist does one or both of two things. *He changes the environment* by interposing certain optical items between the eye and the visual target or field of the patient, and he *changes certain patient reactions to his environment*. Part of the latter is produced incidentally by the use of the glasses and part is produced by visual training which involves various devices both instructional and instrumental.

5. Thus, the optometrist is centered neither on the environment nor on the rigid or fixed features of anatomy as if they alone determined the nature of over-all human reactions. The organism is by its very nature a system able to employ its members (organs and organ systems) in various ways to accomplish various ends. In this technique, the clinical examination is not directed exclusively toward disclosing rigid features of ocular anatomy. Nor is the therapist brought to a standstill in finding some anomalous feature of anatomy. The attention is always centered on the complex facilities at the organism's command, and how these facilities can be used to achieve the desired ends. This is a complete reversal of viewpoint and practice from the conventional procedure of directing attention toward factors which in their quan-

titative characteristics are taken to be isolated, fixed, and unsurmountable limitations of behavior.

6. The patient is looked upon as living in a space world which he has a part in structuring.

7. Physical refractive data are not ignored, but are a part of the findings used to understand the patient (organism), for alterations of such data according to some, systematically alter the organism's behavior. The data from this procedure provide for deductions concerning the means-to-ends which the organism has at its command. With this rationale, the optometric therapist can enter the picture and employ factors toward obtaining effective behavior that naturally would be beyond the grasp or imagination underlying any other procedure.

8. One of the salient features of experimental optometry is the study of the environmental stress put upon the organism by common everyday situations. Whereas osteopathy studies the organism's skeletal and muscular (postural) response to gravitational stress, optometry studies the organism's postural response to the stresses imposed by the field of illumination around it. Notable in this direction is the work of Harmon,[2] whose findings are a help in developing the preventative form of optometry.

Harmon's interest has centered around the distribution and direction of the light in the child's visual environment. In accord with the illumination factors, the child assumes various postures. The ill-distribution of light makes demands upon the child that use energy needed for growth. Growth occurring under conditions of stress is manifested in various forms of distorted performance and structure. The visual system is not omitted in these consequences. Not only are postural imbalances brought about by inappropriate forms of light distribution but such illumination always interfers with three-dimensional seeing. To ignore these matters is to ignore the organism and the ways it must cope with the man-made circumstances of the environment. For a professed biologist to ignore the organism is to become absurd.

In the foregoing, the basic contrasts between medical and certain optometric thinking and therapies have been outlined. What has been said ought to suggest that the rationale underlying therapeutic procedures is a matter deserving inspection to see whether at the very foundation of daily procedures there is something demanding correction or improvement. If there is, it should be expected that practices that stem from it will be inappropriate.

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INSTRUMENT REVIEW

CONOVER-SPAETH MAGNETIC CAMPIMETER. Designed by William Conover and Edmund B. Spaeth, M.D. Manufactured and distributed by George P. Pilling & Son Company, 3451 Walnut Street, Philadelphia, Pennsylvania.

This new Mangetic Campimeter is a metallic tangent screen using an innovation in the presentation of the targets to the patient. Instead of the various size targets being on wands the actual colored test objects are small steel balls which roll on the metallic surface of the screen and are controlled by a magnet held closely to the back of the screen. The magnet is controlled by a small trolley sliding smoothly in a track that turns 360° (for the meridians) and will cover the field of the patient 45° in any direction from the point of fixation.

The metallic screen is a non-reflective grey, presenting a working surface of 21" to the patient. With the patient's eye at 10½" this gives a field area of 45° in any direction from fixation and this is ample for central field studies.

Test objects are supplied in white, red, blue and green: in 1, 2, 3, and 5 mm. sizes.

Claims for the instrument are made for greater accuracy and faster time in field studies. Because of no disrupting influences occurring on the side of the screen next to the patient it is felt that greater patient control is achieved. Furthermore, by the operator being on the side opposite the patient and having full mechanical control of the test object from this position, complete attention can be given, watching the patient's eye for any deviation from the point of fixation. With practice an operator can learn to use the instrument with accuracy and speed.

This author having used a similar metallic screen at 13½" for hundreds of field studies, using hand wands, questions whether any greater speed can be achieved by the magnetic presentation. It will be also interesting to see if the "baring of the blind spot" can be found at

10½" since this loss of function in glaucoma is usually discovered at a meter using very small test objects. Where comparisons of isopters are useful (nasal quadrant loss for green in early glaucoma) meter screens permit a wider size choice of test objects than most shorter working tangent screens.

The designers are to be complimented for the innovations on this instrument and we will be watching the literature for case reports in which the clinical evidence was found on the "Magnetic Campimeter."

HAROLD SIMMERMAN

107 E. MANTUA AVENUE
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CURRENT COMMENTS

Terry Judith Parkins
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department; such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

ON THIS AND THAT IN OPTOMETRY

The summer I had a vacation trip through much of the Mid-West and some of the Atlantic Sea Coast States. One thing which impressed me wherever I went was the use of attractive glasses by people everywhere. Many of todays glasses are beautiful on the patients that wear them. Our frame makers have ultimately turned a drab but useful article into something that people are proud to own and wear.

I talked to men and women I met in restaurants, motels, filling stations and beauty parlors and found them happy with their attractive well fitting spectacles. As we visited I told them that one of my writing assignments was for a scientific magazine in the eye field and many of them then freely talked of their visual problems —their doctors and their glasses.

And I was impressed too at the large number of these people who were happy in the hands of their optometrist. At least 10 out of every 12 I talked with were optometrists' patients and most of these people had been so for years. They usually seemed to know him quite well and seemed to think much of him. I was proud of my association with optometry and glad to learn, in this first hand way, that our readers were doing such a fine job and pleasing so many people.

When I returned I found that an Academy member, Lord Charn-

wood of London had recently spoken in the British House of Lords on the subject of national legislation for optometrists in the British Isles. In speaking disdainfully of commercial and promotional optometric activities, the noble Lord, Lord Charnwood said, "that sort of thing [if permitted] would lead to a nation of spectacle-wearers, as there is across the Atlantic. I spend my time telling people to throw their 'specs' away."

His talk was widely quoted in the British press and judging from their professional journals his comments struck a rather sour note with many British optometrists. Well, there are a number of his fellow Academy members over there who can handle the scientific side of such an argument, but as a writer I would like to make one observation. I wear glasses—I am told they are not "strong"—but I know I fell better with them than without. Perhaps I *could* get along without them—but, why should I do so—or for that matter, why should other patients, or why should the British public if glasses make us all see better and feel better. In rereading the discussion in the British journals on this subject it looks as if Lord Charnwood had a bad day—but don't we all on occasion?

One of my nearsighted friends has just been fitted with contact lenses, and after several weeks in which she has accomplished nothing else, she has finally lost her fear of them. In her own fumbling way she has learned to insert them and get them out again, and to use them for a few hours at a time. She has corneal lenses—little things—but not the new "microlenses" recommended by Dr. John Collins Neill of Philadelphia. After watching her performance, let us hope his new lenses work better than the lenses she has. Few patients would go through the ordeal she has been through, when wearing spectacles is so simple and satisfactory and accomplishes just as much.

Well—after that paragraph, if I had any friends in the Contact Lens Section, I suppose I have lost them now. Lord Charnwood—please *move over* in that dog-house of yours and let me crawl in with you.

The need for good vision on the part of employees and the ever present requirement of eye safety plans in industry will highlight the November 18 meeting of the Southern Occupational Vision Council at Georgia Tech, Atlanta. This will be a joint meeting of management people, optometrists, opthalmologists, industrial nurses, architects and illuminating, safety and industrial engineers. Optometrists interested in occupational optometry, and all should be, are invited to meet with the Council.

Editor Koch represents Optometry on the Healing Arts Educa-

tional Advisory Committee to Selected Service in Washington. He receives much mail from them at his Minneapolis office and the other day they quoted Emperor Haille Selassie's mobilization order to the Ethiopians when Mussolini began the invasion of that country in 1935. The order follows:

"Every one will now be mobilized and all boys old enough to carry a spear will be sent to Addis Abba. Married men will take their wives to carry food and cook. Those without wives will take any woman without a husband. Women with small babies need not go. The blind, those who cannot walk, or for any reason cannot carry a spear, are exempted. Anyone found at home after the receipt of this order will be hanged."

And there are some optometry undergraduate students who kick about the rigidity of our present student deferment program.

Six optometric educational congresses all sponsored by the Optometric Extension Program are listed for coming months. These include the North Central Congress, October 3-4-5 in Minneapolis; the New York All State Congress in Elmira, October 10-11-12; the Northeast Congress scheduled for Boston, October 16-17-18; the Middle-Atlantic Congress in Pittsburgh, October 24-25-26; the Heart-of-America Congress in Kansas City, October 31, November 1 and 2; and the Northwest Congress which will be held in Portland on December 12-13-14. You are invited to attend the meeting nearest you.

The statistics experts get into some fine hassles on just how to figure the mean, the mode, Chi-square, etc., and what the answers really stand for. After looking over some of the correspondence (these scraps are largely carried on by mail), I remembered something which appeared in the August issue of the ARMED FORCES MEDICAL LIBRARY NEWS. It read, "Thompson quotes Lord Kelvin who said 'When you can measure whatever you are talking about, and express it in numbers, you know something about it. But when you cannot measure it in numbers your knowledge is of an inadequate and unsatisfactory kind.' At the other pole is Mark Twain's well-known statement about 'lies, damned lies, and statistics.' And what the LIBRARY OF CONGRESS INFORMATION BULLETIN had to say about the Princeton Statistics—'they raise as many questions as they answer'—and perhaps that is one of the extra dividends to be derived from them."

Dr. John R. Kennedy, St. Paul has been elected president of the Northern Illinois College of Optometry Alumni Association, and Dr. Louis Jaques, Los Angeles and Dr. Raymond Roy, Portland, will be the speakers at the Fall Educational Seminar of the Wisconsin Opto-

metric Association, Wisconsin Hotel, Milwaukee, October 23-25. Dr. Marilyn Brenne of Manitowoc, Wisconsin is in charge of the meeting.

Naturally the questions are changed each year but a review of prior years questions would be helpful to those undergraduate students in our professional courses who are planning to take the tests next June. For this reason the National Board of Examiners in Optometry has now made available the prior examination questions for the years 1953 ($1.00) and 1954 ($2.00). Copies of these may be had by sending your order to the secretary, Dr. John Uglum, Crow Building, Mitchell, South Dakota. Checks should accompany the letter.

California optometrists are cooperating with the officials of the State Department of Fish and Game by screening the distance visual acuity and the horizontal visual field of hunters who apply and giving these applicants a visual record card on which such data are recorded. Minnesota optometrists are doing somewhat the same thing in co-operation with the Highway people when they certify the vision of applicants for State drivers license.

A number of students enroll in professional courses in optometry at the suggestion of optometrists who are already in practice. Another good way to develop interest in selecting optometry as a career is reviewed by Dr. Ralph H. Green, Dean, Massachusetts College of Optometry. Dr. Green reports that plans have been completed with Suffolk University, member of the New England Association of Colleges and Secondary Schools, for the offering of a pre-optometry program of study designed to meet the entrance requirements for admission with advanced standing to the second year class. Similar pre-optometry curricula have been established since 1949 at Cambridge Junior College and Worcester Junior College.

CORRESPONDENCE

AUTHOR'S COMMENT ON VARIATION IN ACA RATIO*

To the Editor:

We are indebted to Hirsch† for defining constancy and for so clearly marking the point of difference between the present authors and the editorial council of this publication. It is to their credit that they

*Manus, Leo, and Shulman, Paul. The Variation in the Accommodative-Convergence Accommodation (ACA) Ratio Upon Periodic Retesting. Am. J. Optom. & Arch. Am. Acad. Optom. 31.8.385-395. 1954.

†Hirsch, Monroe J. Editorial Footnote to Manas & Shulman Paper. Am. J. Optom. & Arch. Am. Acad. Optom. 31.8.395-396. 1954.

were willing to publish and present this "other viewpoint."

Hirsch considers blood pressure as a typical example of a biological constant. The present authors disagree completely with this viewpoint. If we apply his definition of a biological constant—something that does not vary systematically—to blood pressure, we have just the converse—blood pressure does vary systematically with age, environmental activity, oxygen content of the air and with body weight. We accordingly consider blood pressure as an example of a biological variable, whose magnitude can be estimated only after all of the above factors have been evaluated.

Hirsch considers the measurement of a room with a millimeter rule as an example of "error of measurement." He starts with the Fixed room and, therefore, any variation in the length of the room Must Be Due To Either The Error in the Measuring Instrument or to Errors of Observation. With this concept we are in complete agreement. We wonder at Hirsch's reaction if we were to change the circumstance a little. A blindfolded observer is placed inside of a dark enclosure—the blindfold is removed, and he is asked to take a luminous ruler and measure the distance between two luminous guidepoints. We wonder if Hirsch were this observer would he be content to consider the variation as errors of measurement when he found such changes as 6000 mm. the first time, and 8400 mm. the second time. This is the magnitude of the average variation found in the measurement of the ACA ratio.

The units which we have been considering above are relatively simple measuring units such as millimeters. In the case of the ACA ratio we have a complex unit—it involves accommodative units and convergence units. The ACA ratio is thus a different type of a unit of measurement. It expresses the slope of a line or a rate of change and it is a pure abstraction. The ACA ratio is thus a way of expressing a relationship between Variables. If we use the Fry method of calculation, page 393, how can we have a constant ACA ratio when the very equation from which it is calculated tells us that it will vary as the difference between the far and near induced phorias. In fact, since the magnitude of the far phoria is low in comparison to the near phoria, for our purpose we can predict that the ACA ratio must vary directly as the near phoria test. This is precisely what we found experimentally.

In the face of all our precautions taken to minimize experimental error in our research project it is difficult to account for the large variations in the ACA ratio which were found as due to "error of observation." These are the points of disagreement regarding this report. We do, however, have areas of agreement, these are: (1) There is a rela-

tionship between accommodation and convergence, and (2) There is a large variation in the magnitude of the ACA ratio for a particular individual.

LEO MANAS
PAUL SHULMAN

BOOK REVIEW

THE OPTOMETRIST'S HANDBOOK OF EYE DISEASES. Joseph I. Pascal and Harold G. Noyes. Published by C. V. Mosby Company, St. Louis, Missouri. 300 pages. 155 illustrations. 3 color plates. Cloth. $9.00. 1954.

The title of this book is accurate inasmuch as this is a *handbook* and not a full and comprehensive treatise. With but three color plates on such an important topic of eye pathology it is evident the compromise to eliminate detail with adequate coverage has led to a volume which could not replace Duke-Elder or any other standard reference on the subject. This lack of color fundi plates is the chief disadvantage of a text on eye diseases.

Chapters devoted to day and night blindness, endocrines, heredity and genetics, questions and answers on eye pathology make the treatise especially valuable for those desiring a more complete extended study, but with less exacting detail. Consequently, the volume is excellent as a review by practitioners in the field who are concerned with the more popular eye anomalies and diseases and less with the theoretical or rare abnormalities of the eye and its appendages.

The lack of sufficient detail would indicate the authors, both practicing ophthalmologists, are not fully cognizant of the rapid increase in optometric educational institutions as far as eye pathology study is concerned. The younger graduates will find the book much too elementary. The greatest appeal may be found by the older practitioner who does not desire the full story on *both* rare and common eye pathologies and anomalies.

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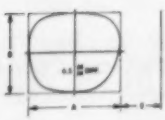

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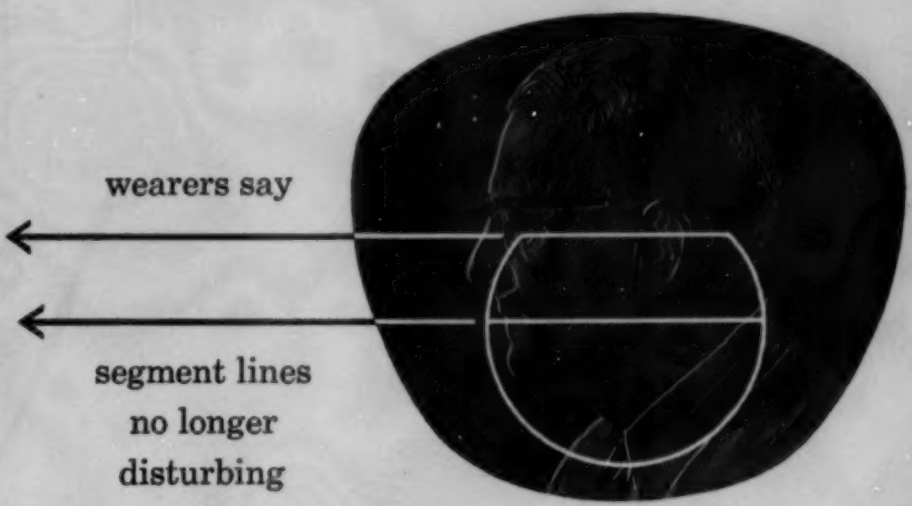

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